Main results of the experimental and theoretical research completed in 2014

1. Discovery of Cobalt-56 gamma-ray lines from a type Ia supernova (SN2014J) in M82.

Astrophysicists from IKI and their colleagues from INTEGRAL team discovered gamma-rays from radioactive cobalt-56 decay from the type Ia supernova in nearby galaxy M82. Thermonuclear burning of carbon and oxygen in the ultra-dense matter of White Dwarfs (density on the order 10^9 g/cm^3) produces large amount of radioactive nickel-56. Subsequently nickel decays to cobalt-56 and then to stable iron-56. INTEGRAL observatory for the very first time found gamma-lines characteristic for the cobalt-56 decay. These results provide an unambiguous proof of the theoretical concept of SNIa's as giant thermonuclear explosions of white dwarfs.

Original paper:

E.Churazov, R.Sunyaev, J.Isern, J.Knödlseder, P.Jean, F.Lebrun, N.Chugai, S.Grebenev, E.Bravo, S.Sazonov, M.Renaud, “^{56}CO γ-ray emission lines from the type Ia supernova SN 2014J”, **Nature**, 512, 406, **2014**, http://dx.doi.org/10.1038/nature13672

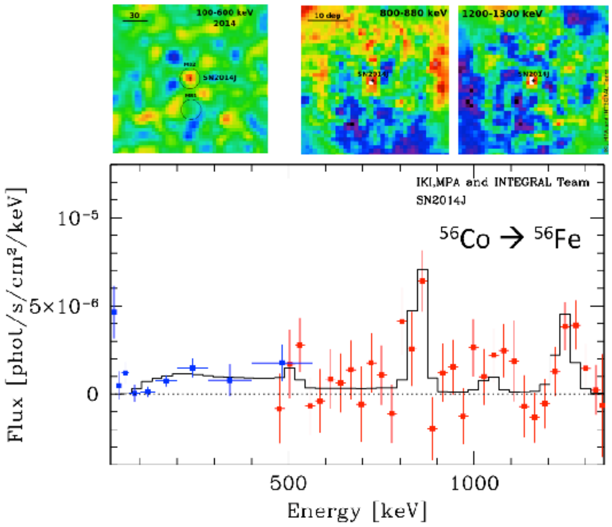

Fig 1. Spectrum of type Ia SN2014J obtained by INTEGRAL, 50 to 100 days after the explosion. Red and blue points show data from the two instruments SPI and ISGRI/IBIS respectively. The black curve shows a fiducial model of the supernova spectrum for day 75 after the explosion. The top row shows images obtained in three high-energy spectral bands by INTEGRAL. A gamma-ray source is clearly visible in all images at the (optical) position of SN2014J.

2. Comprehensive study of high-energy processes in the Earth's atmosphere

1. Microsatellite ”Chibis-M” was developed on the platform originally designed at the Special Engineering Department of Space Research Institute of Russian Academy of Sciences in 2011. Spacecraft was placed in orbit on 25 January 2012 under the auspices of the Russian Academy of Sciences and S.P. Korolev Rocket and Space Corporation ”ENERGIA”. The main goal of the ”Chibis-M” project is to study lightning phenomena at the upper atmosphere of the Earth. The principal idea underling the scientific payload of the ”Chibis-M” design was the joint observations of the lightning emission at different parts of the electromagnetic spectrum. To realize this idea the following set of instruments was installed onboard: Radio Frequency Analyzer (RFA), UV and IR detectors (DUF), Roentgen and Gamma detector (RGD), Plasma Spectrum Analyzer (PSA) and Fast Optical Camera (FOC) [1]. Principal investigators of the microsatellite are academicians L.M. Zelenyi and A.V. Gurevich. It was realized microsatellite launching scheme by means of the infrastructure of the Russian segment of the ISS (Fig. 1), supposed to be used for those in time schedule 2017-18g.g. To manage data downlink and mission control tracking headquarters was organized on the basis of the Space Research Institute of RAS. Tracking headquarters fully provided the completion of the scientific program of the "Chibis-M" (25.12.2012-15.10.2014), as well as the downlink, storage and processing of scientific data.

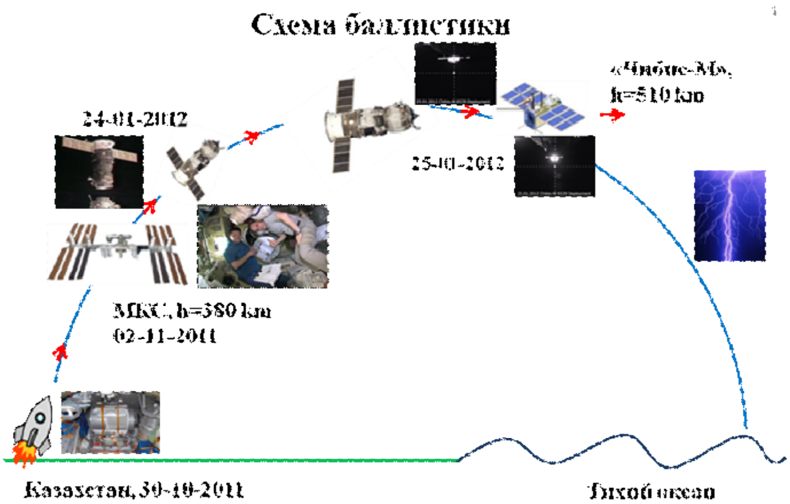

Fig .1. Ballistic scheme of the “Chibis-M” microsatellite.

2. For the first time it was conducted at altitudes of 250 - 500 km comprehensive studies of ultraviolet (UV) and infrared (IR) radiation, gamma rays, VHF and ELF / VLF radiation from thunderstorms [1, 4]. At this stage, a number of characteristic phenomena were studied.

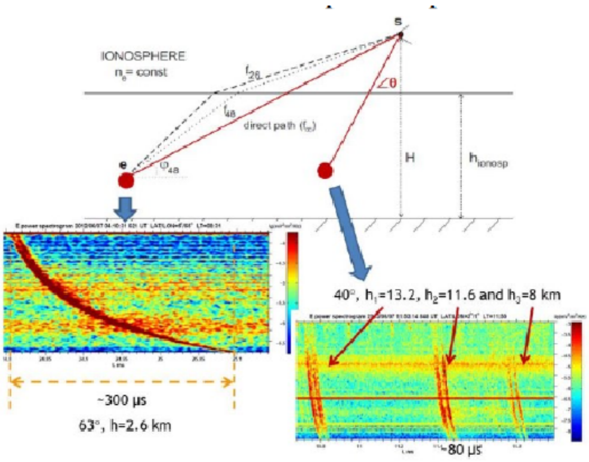

Fig. 2. Example of the first type of the VHF emission detected by the “Chibis-M”.

3. According to the radio-frequency analyzer (range 26-48 MHz) it was noted two types of scenarios for the high-altitude discharge [4-6]. A distinctive feature of the first scenario of "breakdown" are paired broadband pulses of the order of several microseconds, and the delay between pulses 6-120 microseconds. This study supports the hypothesis that the second pulse is a reflection of the initial source emission from the Earth's surface. This fact allows us to determine the height of the source (see Fig. 2) [6]. In some cases, this type of event accompanied by the IR and UV radiation. The most active areas on the Earth's surface are: Central America, the west coast of Africa and the Malay Archipelago.The second scenario of lightning activity is the generation of broadband "noise" with typical duration from some hundreds of microseconds to several milliseconds. Registration of "noise" in most cases is accompanied by bursts of VHF of the first type. The amplitude spectrum of the "noise" suggests a possible "clustering" emitters [5].

4. It was created database of ionospheric electromagnetic radiation range 0.01-40 kHz characterizing the global thunderstorm activity and electromagnetic parameters of space weather [1, 3].

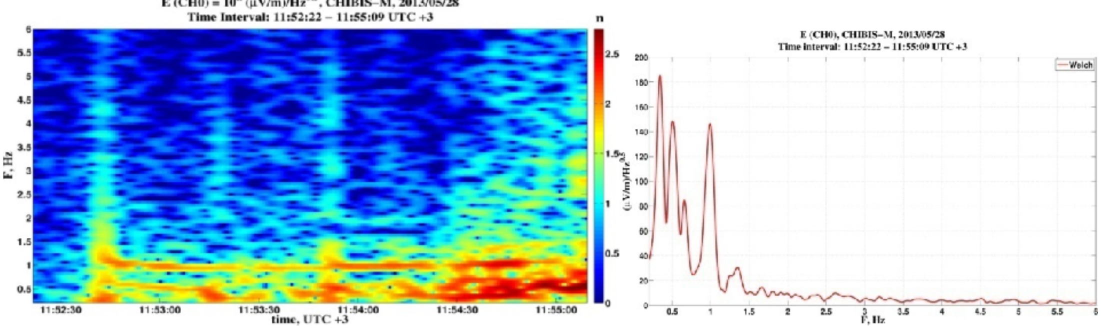

Fig. 3. Example of detected electromagnetic structures of the ionospheric Alfven resonator (frequency of about 0.5 Hz to ~ 5 Hz) excited by atmospheric thunderstorm activity [2].

List of publications

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4. Dolgonosov Maxim, Lev Zelenyi, Vladimir Gotlib, Dmitry Vavilov, Stanislav Klimov, VHF emission from lightning discharges recorded by “Chibis-M" microsatellite. 40th COSPAR Scientific Assembly 2014. Advances in Remote Sensing of the Middle and Upper Atmospheres and Ionosphere from the Ground and from Space, including Sounding Rockets and Multi-instrument Studies (C0.2).
5. Dolgonosov Maxim, Lev Zelenyi, Vladimir Gotlib, Dmitry Vavilov, Stanislav Klimov, A.V. Gurevich, Observation of the compact intercloud discharges onboard of microsatellite Chibis-M, Proceedings of International Symposium TEPA, 2013, Armenia.
6. M.S. Dolgonosov, V.M. Gotlib, V.A. Rakov and L.M. Zelenyi, VHF emission from lightning discharges recorded by “Chibis-M” microsatellite, Proceedings of International Conference on Atmospheric Electricity, 2014, USA.
7. Vavilov, D.I., Shklyar D.R. Ionospherically reflected proton whistlers // J. Geophys. Res. Space Physics, 119, doi:10.1002/2014JA020510, 2014.
8. Долгоносов М.С., В.М. Готлиб, Д.И. Вавилов, Л.М. Зелёный, УКВ радиоизлучение от грозовых разрядов, регистрируемое микроспутником «Чибис-М» // Труды 18-й Международной конференции молодых ученых «Состав атмосферы. Атмосферное электричество. Климатические процессы». Борок, Ярославская обл., 2014
9. Dolgonosov M.S. , V.M. Gotlib, V.A. Rakov, L.M. Zelenyi VHF emission from lightning discharges recorded by “Chibis-M” microsatellite // Proceedings of XV International Conference on Atmospheric Electricity, 15-20 June 2014, Norman, Oklahoma, U.S.A.
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